

Final Project

Minerva University

CS130: Statistical Modeling: Prediction and Causal Inference

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Executive Summary

This paper is a response to the 2021 study “Philadelphia’s Excise Tax on Sugar-Sweetened and Artificially Sweetened Beverages and Supplemental Nutrition Assistance Program Benefit Redemption” by Benjamin W. Chrisinger. Motivated by unexpected effects on lower-income shoppers' behavior and increased SNAP benefit redemption in neighboring counties, we aimed to replicate the synthetic control method and conduct a robustness check. Our analysis seeks to understand two causal results from the paper: 1) **whether the excise tax on sugar and artificially sweetened beverages could indeed reduce the consumption of them among the low-income consumers in Philadelphia County**; 2) **whether this excise tax led to increased SNAP benefit redemption in the neighbor counties, potentially meaning that low-income individuals in Philadelphia County traveled to shop**. While we are able to replicate similar trends, the magnitude of the effects differs, and our models lack robustness. We attribute these disparities to data access limitations and variations in synthetic control implementations. Until these discrepancies are addressed, we withhold definitive conclusions regarding the impact of the introduced excise tax in Philadelphia County and its neighboring counties.

Link to the Paper: <https://ajph.aphapublications.org/doi/full/10.2105/AJPH.2021.306464>

Link to the Paper’s Code and Data Access:

<https://ora.ox.ac.uk/objects/uuid:74e97397-1f7b-4b44-b22c-899d74fa0b83>

Link to Our Code: <https://rpubs.com/chiffonng/cs130-final>

Introduction

The study by Chrisinger (2021) explores the effect of excise tax on sugar-sweetened and artificially sweetened beverages on SNAP participants' benefit redemption in Philadelphia County and its neighbor counties. The Supplemental Nutrition Assistance Program is a national program for low-income individuals in the U.S. that provides redeemable benefits on food items. Thus, by tracking SNAP benefit redemption, we can learn about low-income shoppers' behaviors. The study finds that after introducing the excise tax in Philadelphia County in 2017, in two consecutive years, the total SNAP benefit redemption increases in all 3 neighboring counties (Bucks, Delaware, Montgomery). Moreover, the per-individual SNAP benefit redemption increases in Delaware and Montgomery counties and decreases in Philadelphia.

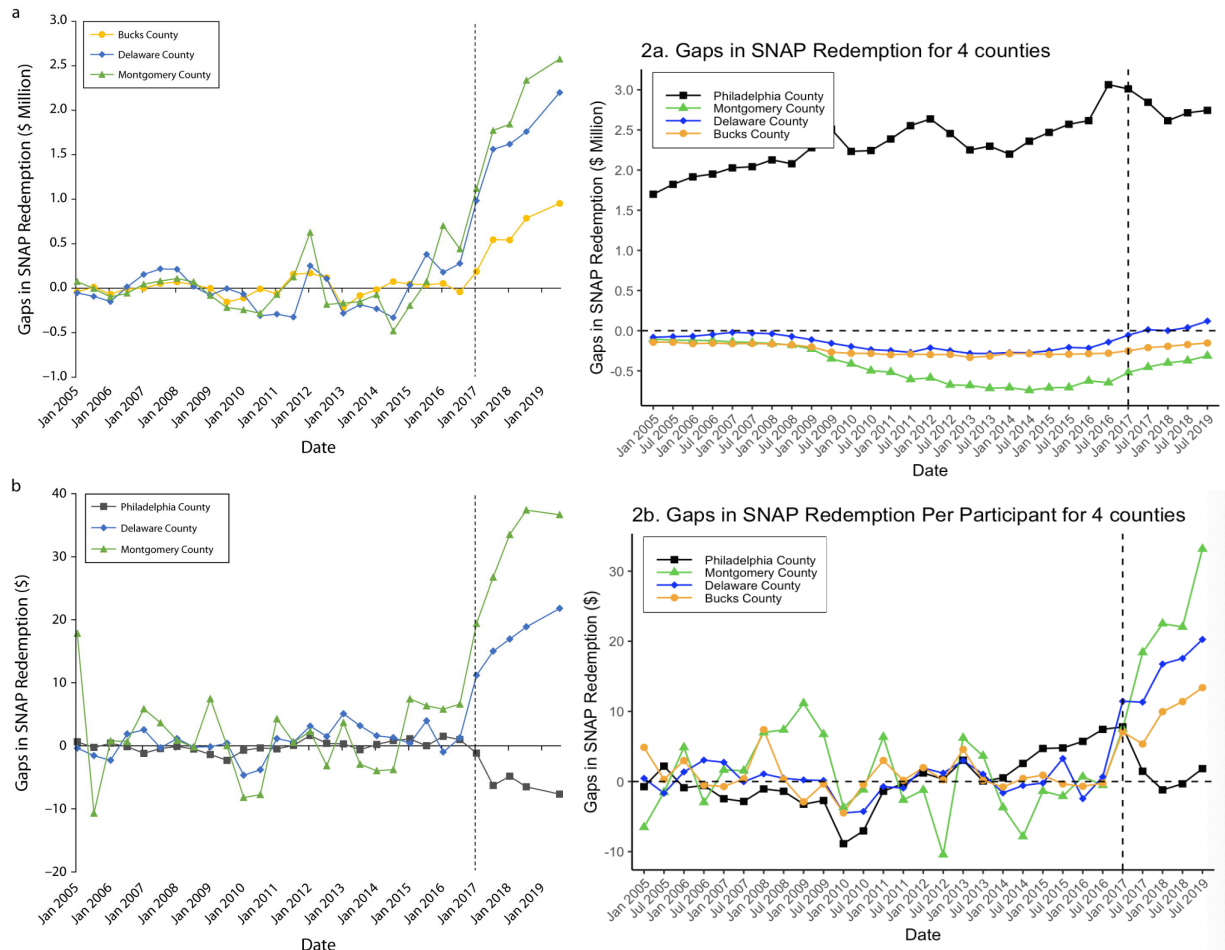
To gauge the excise tax's impact, the study employs the synthetic control method, generating gap visualizations between synthetic and actual Philadelphia, repeating the process for its three immediate neighbors (see Figure 1). The observed substantial impact prompts us to replicate the study to validate these results. It's important to note that we had limited access to some datasets used in the author's code, only obtaining the final dataset, which required extensive cleaning and reorganization.

Additionally, while the author claims to have conducted a leave-one-out analysis to assess the model's robustness, we couldn't access this analysis, although it is claimed to be in the paper supplementary. Thus, we extend the study by performing, visualizing, and evaluating the model with the leave-one-out analysis.

Replication

To test if we receive similar results on low-income shopper's behavior before and after

the excise tax, we replicate the Figures 2a and 2b from the original study. We provide the comparison in Figures 1 and 2.



Figures 1 ([original study figure 2](#)) and 2 (replicated). Figure 1a is a gap plot between the treated and synthetic control in total SNAP redemption (in millions of dollars) of Bucks, Delaware, and Montgomery counties. Figure 1b is a gap plot of Philadelphia, Delaware, and Montgomery Counties for the SNAP redemption is per participant in U.S. dollars. Figure 2 is our replication of these results, using the final dataset that was provided together with the published study. Dashed vertical line indicates the tax implementation in Philadelphia in January 2017. Although the replicated results have similar trends to the ones in the original study (especially in Figure 2b), the gaps seem to not match the original study.

The author reports that there is no appropriate synthetic control for Philadelphia County

(Figure 1a) and no detectable treatment effect found for Bucks County (Figure 1b). We made the best attempt with the available dataset to replicate the gaps plot after running synthetic controls for the four counties; however, some predictors used in the study were excluded in our synthetic controls due to *multicollinearity*. In Figure 2a of our replication, it's evident that an appropriate synthetic control fit for Philadelphia County is lacking, with gaps consistently above 0 well before the 2017 excise tax. Other counties in our replication (Figure 2a) exhibit similar trends but with a smaller effect than the original study (Figure 1a), and less variability in the pre-treatment period.

Figure 2b (replication) displays trends similar to Figure 1b (original study), but with different gap results, particularly for Montgomery County, which appears to lack an appropriate synthetic control fit in our case. While the study notes a positive post-treatment effect for Bucks and Delaware Counties (not plotted in our replication since no significance testing is performed), the replication graph alone makes it challenging to assess if Philadelphia County experiences a negative post-treatment trend, given the similarity of gap values to some instances in the pre-treatment period. Considering that we only had access to the final dataset of the study and are unsure of all manipulations and cleaning performed for smaller datasets that were used but we could not access, we attribute the inconsistencies to this matter. This could also be because we had to exclude some predictors used in the original study due to multicollinearity issues. However, there is a possibility that the effect in the original study was an overstatement and we encourage the author to share the rest of the datasets to learn whether the results can actually be replicated.

Extension: Leave-one-out Robustness Check

As an extension of the original study, we perform the leave-one-out sensitivity analysis for SNAP Redemption per participant for Philadelphia County and its neighboring counties. Here, we chose to present Delaware County, due to its consistency between our replication and the original study.

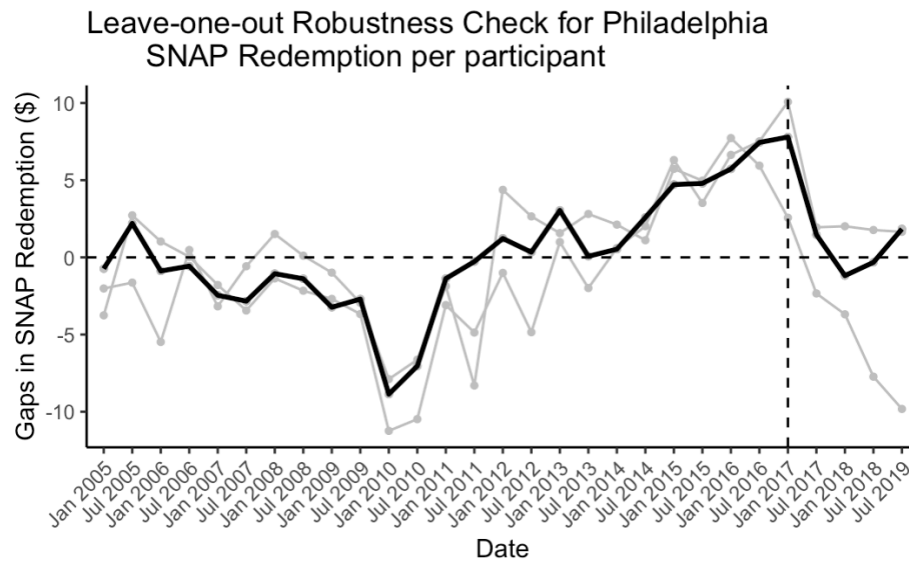


Figure 3. Leave-one-out Robustness Check for Philadelphia County, PA for SNAP Redemption per Participant. There are very few synthetic controls produced during the leave-one-out analysis (due to the small donor pool of Philadelphia) and each looks different in the pre-treatment period, suggesting that the model for Philadelphia is not robust.

The analysis for Philadelphia is visualized in Figure 3. By excluding a different county from a donor pool each time we run the synthetic control, we can observe whether any of the counties have significant weights in creating the synthetic Philadelphia County. If so, the model would not be considered robust. In Figure 3, we see that first of all, very few synthetic controls

were produced for Philadelphia County, meaning that there are very few counties in the U.S. similar to Philadelphia. Furthermore, the model struggles to match effectively in the pre-treatment period, indicating that it is not robust.

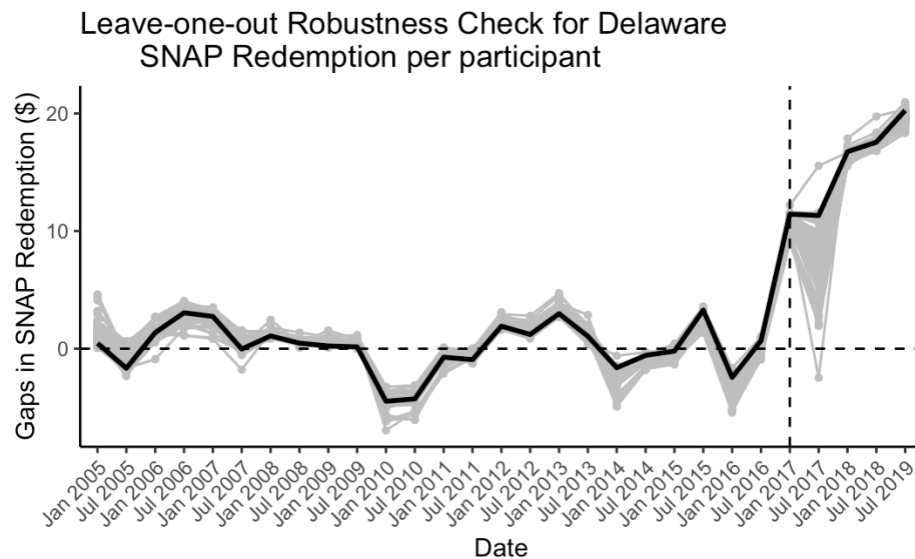


Figure 4. Leave-one-out Robustness Check for Delaware County for SNAP Redemption per Participant.

This time there are many synthetic controls produced and most of them are very close to the original synthetic control during the pre-treatment period. Some divergence in post-treatment period could be attributed to model sensitivity or to external factors leading some counties to have similar patterns even without the excise tax. The model seems to be relatively robust.

In Figure 4, the leave-one-out robustness check for Delaware appears quite different from Philadelphia County. For the pre-treatment period, the synthetic controls produced with leave-one-out analysis are very similar to the one when all the counties remain in the donor pool. The divergence in the post-treatment period could be attributed to either model sensitivity or external factors, which could have led to similar patterns in some counties that did not experience the excise tax in the neighboring counties. Compared to the model produced for

Philadelphia County, this seems to be relatively robust.

Conclusion

After performing this analysis, we conclude that the inconsistencies we observed between the synthetic control in the original study and our replication and lower than expected robustness of the model could be attributed to potential differences in the data used and the analysis performed. Although we attempted to follow the criteria for cleaning the data that was mentioned in the paper and parts of the code, the inconsistencies remain. We encourage the author to include the smaller dataset in the code and data folder that is provided along with the study in order for the legitimacy of the claimed results to be tested. Currently, we would restrain from making inferences about the excise tax on sugar and artificial sweetened beverages effect on lower-income shoppers' behavior in the county where the tax is introduced and its neighbor counties.

Contributions

Chiffon: dedicated extensive amount of time to clean the data, write the code to replicate the figure and to produce the leave-one-out analysis. Contributed to the write-up by helping to interpret the results and reviewing.

Aida: reviewed the code, contributed to the leave-one-out analysis and debugging. Produced the write-up of the assignment, ensured the following of assignment instructions.

AI Statement: We used ChatGPT to help produce the plot using more complex packages and debug the code.

References

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